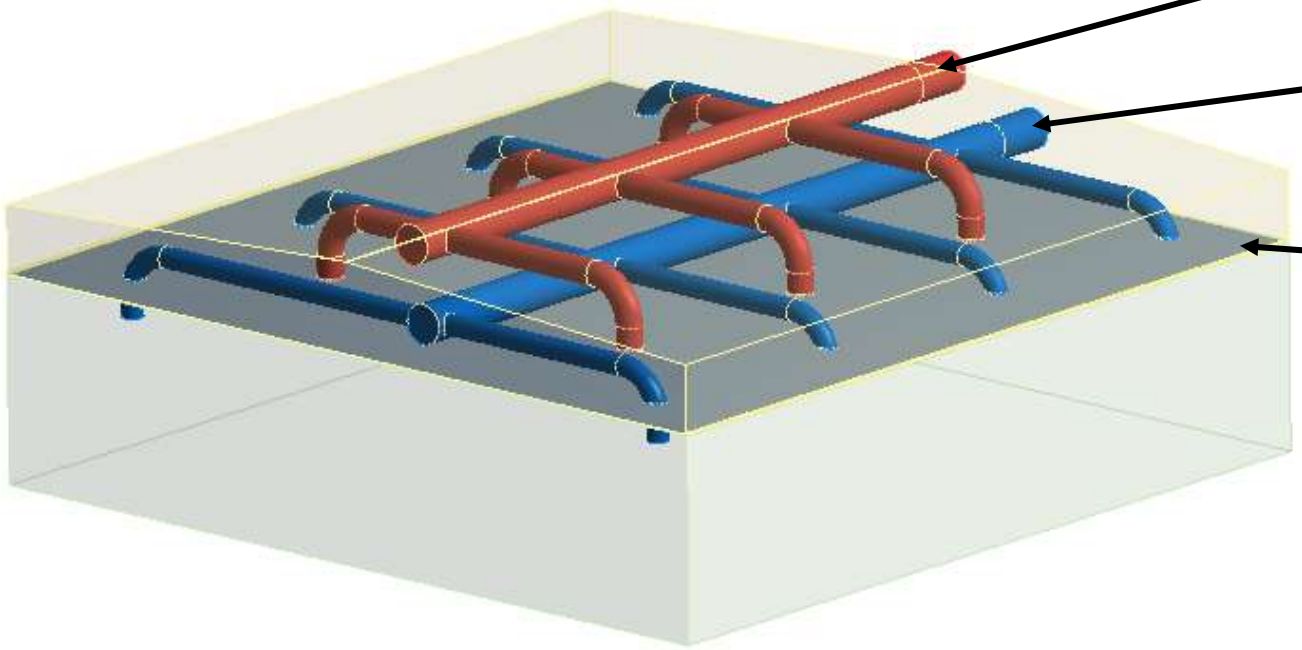
Arcoplast

Energy Savings Analysis

Food Processing Facility Case Study

10,000 ft^2 Food Processing Facility Case Study Model

Dimensions: 100’ x 100’ x 27’
Outside Ambient: 95 F
Solar Load: 1040 W/m^2
Desired Internal Floor Temp: 40 F

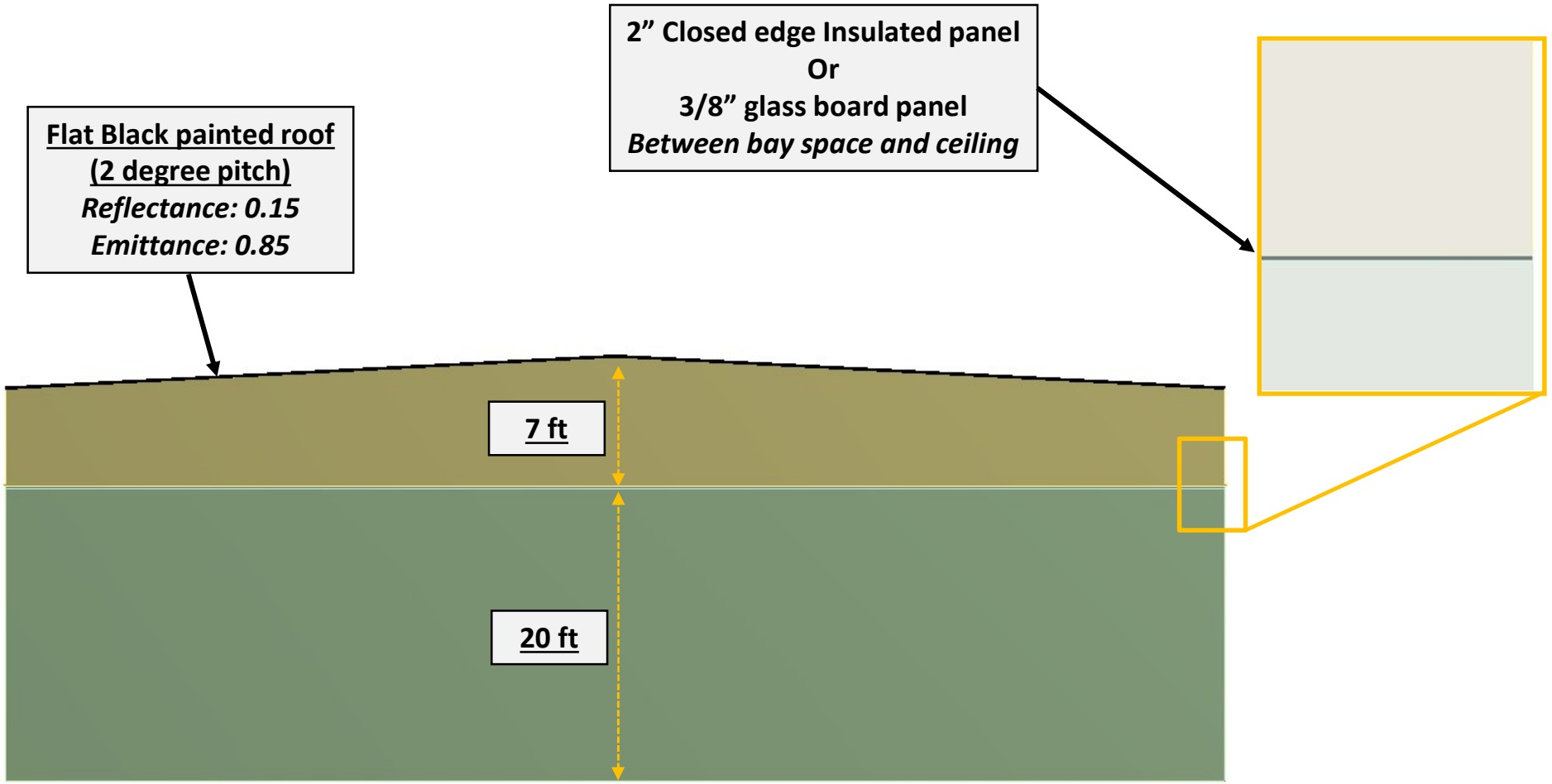


Return Warm Air Return

Conditioned Cool Air Inlet
25 Air exchanges per hour

Ceiling panels
Between bay space and ceiling

10,000 ft^2 Food Processing Facility Case Study Model



Ceiling Panel Insulative Properties

Panel	Actual thickness (in)	Thermal Conductivity (W/m-K)	Thermal Conductivity (BTU-in/hr-ft^2-F)	Leakage at 0.01 in-H2O ΔP (CFM/ft^2)
½" Closed Edge Insulation panel, Gel Coat Finish	0.654	0.040	0.276	0.0
1" Closed Edge Insulation panel, Gel Coat Finish	1.153	0.037	0.255	0.0
1-½" Closed Edge Insulation panel, Gel Coat Finish	1.678	0.036	0.252	0.0
2" Closed Edge Insulated panel, Gel Coat Finish	2.171	0.038	0.260	0.0
3/8" glass board panel	0.366	0.101	0.698	0.0

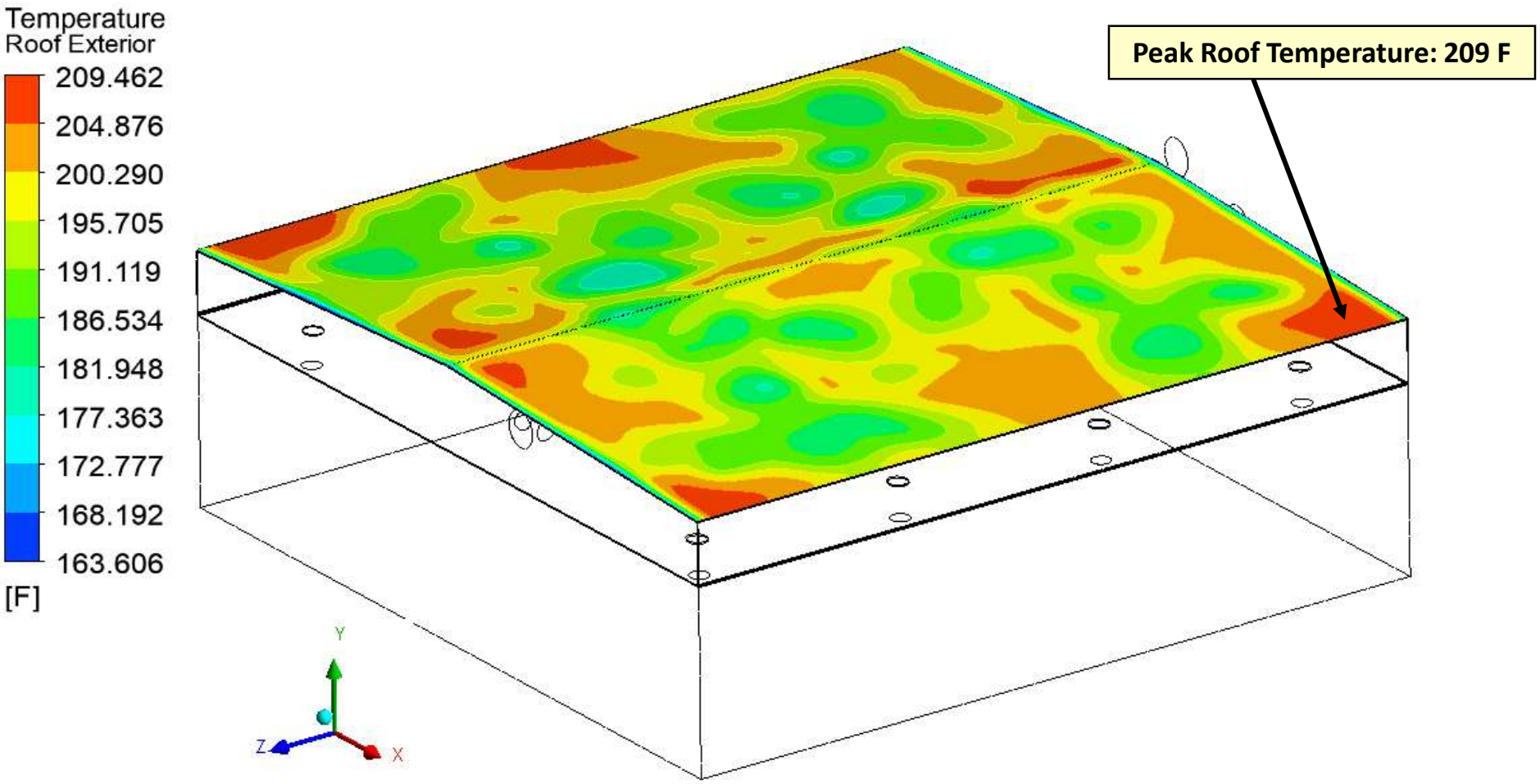
Food Processing Facility Case Study

Nominal 3/8” Glass Board Panel

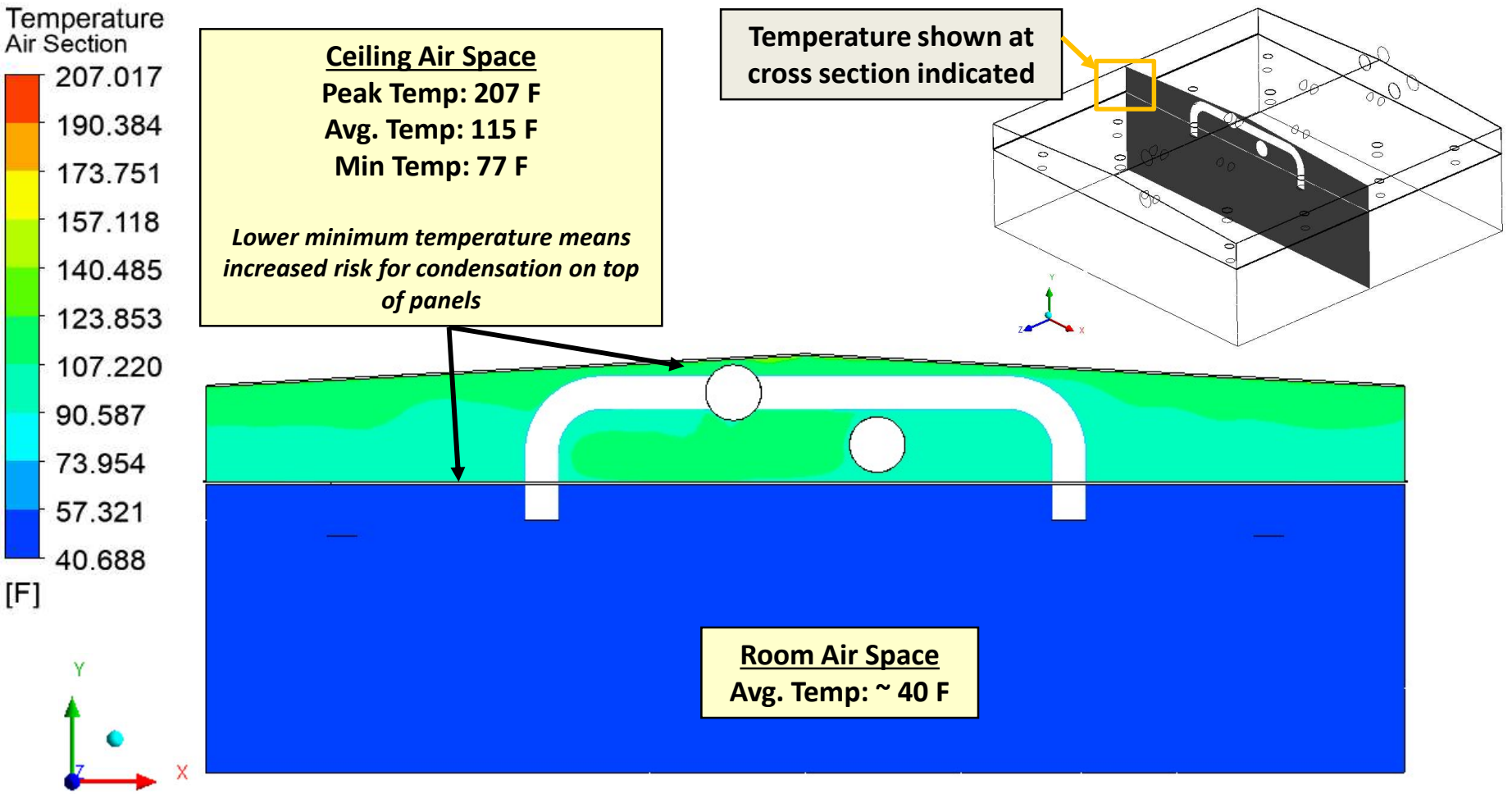
(Actual thickness: 0.366 in)

95 F ambient during the day

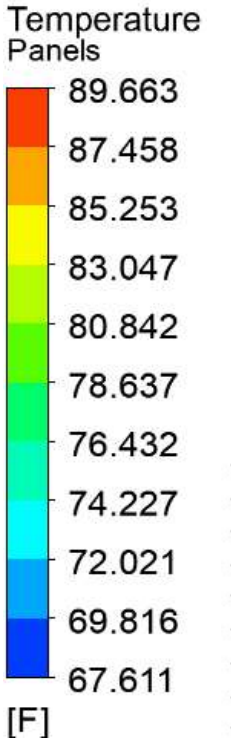
Food Processing Facility Model Results - 3/8” Glass Board

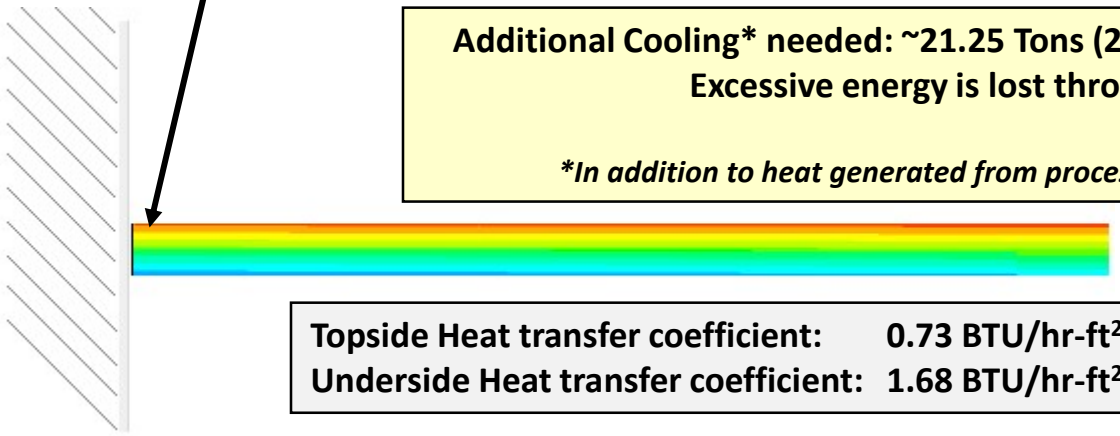


Food Processing Facility Model Results - 3/8” Glass Board

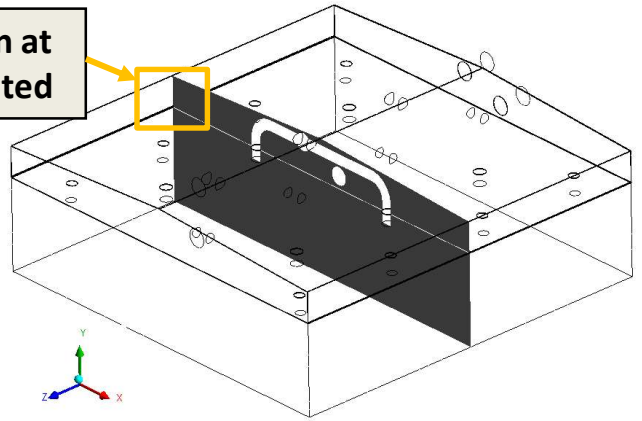


Food Processing Facility Model Results - 3/8” Glass Board





Temperature shown at cross section indicated



Panel Delta T: ~22 F
Does not insulate well

Additional Cooling* needed: ~21.25 Tons (255,000 BTU/hr per 10000 ft²)
Excessive energy is lost through the panel

In addition to heat generated from process equipment and persons

Topside Heat transfer coefficient: 0.73 BTU/hr-ft²-F
Underside Heat transfer coefficient: 1.68 BTU/hr-ft²-F

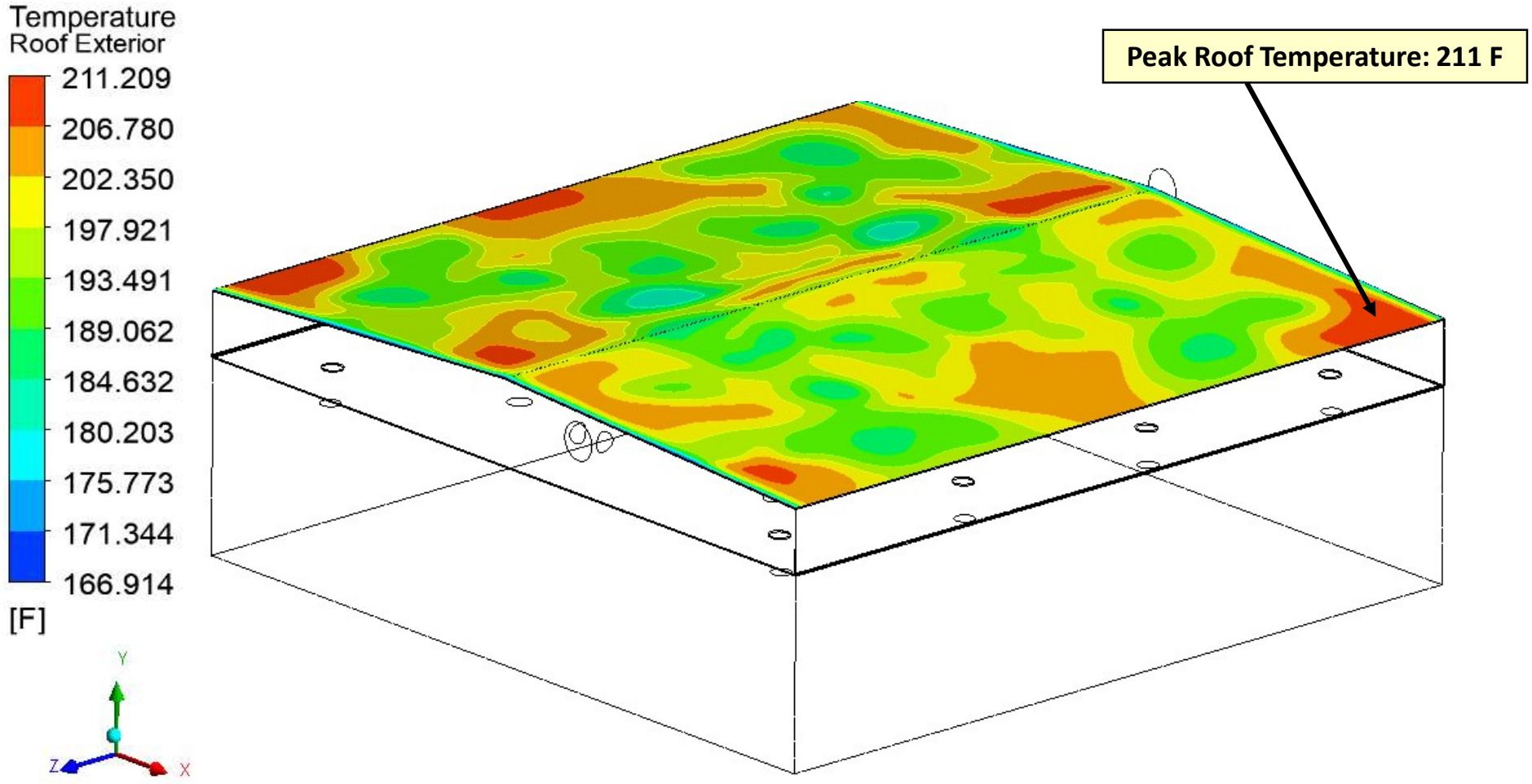
Food Processing Facility Case Study

Nominal 2” Closed Edge Insulating Panel, Gel Coat Finish

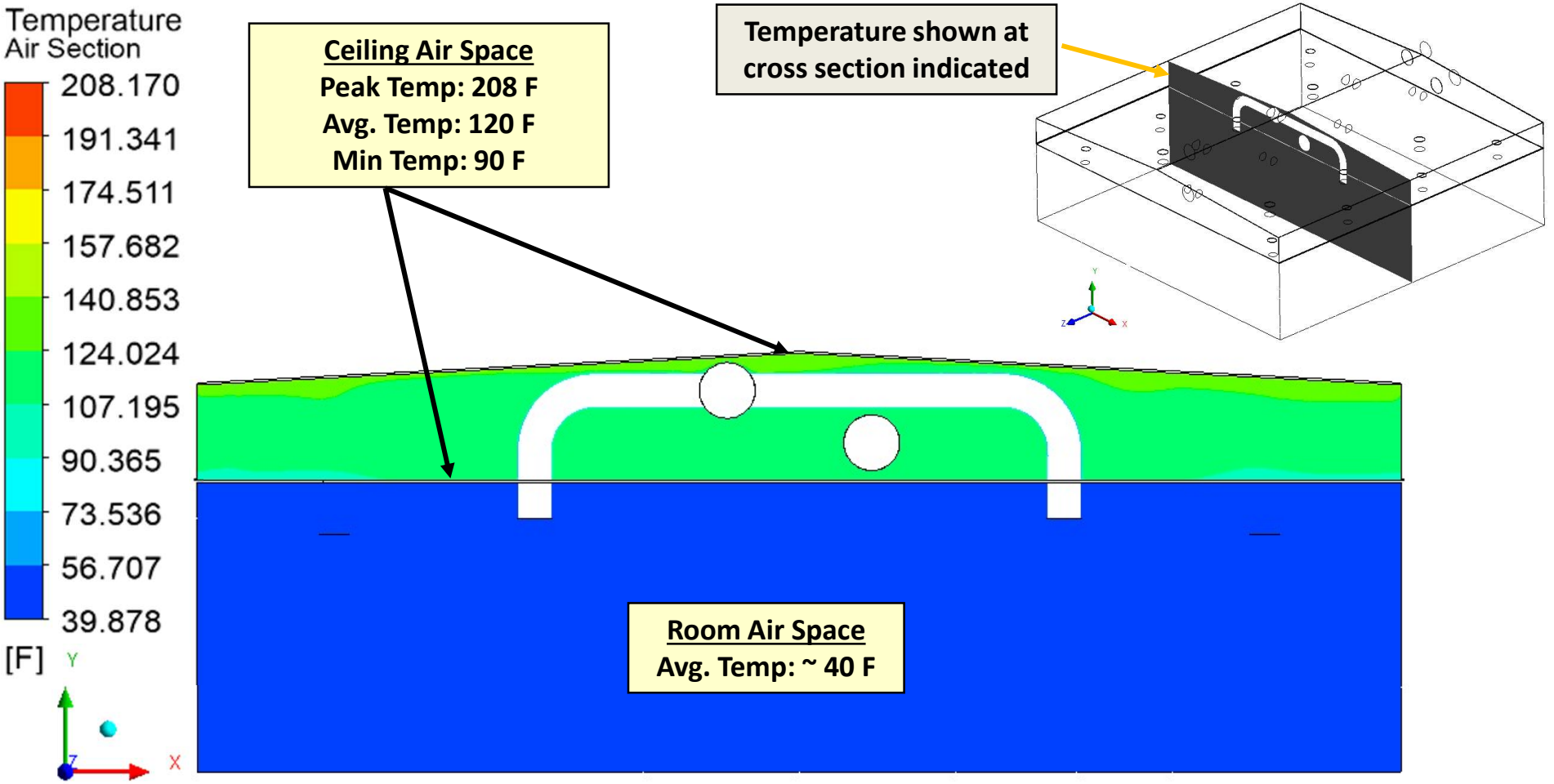
(Actual thickness: 2.171 in)

95 F ambient during the day

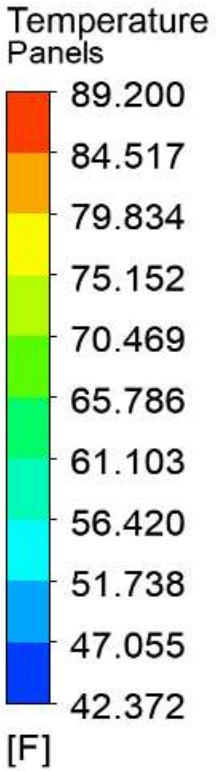
Food Processing Facility Model Results - 2” Insulated



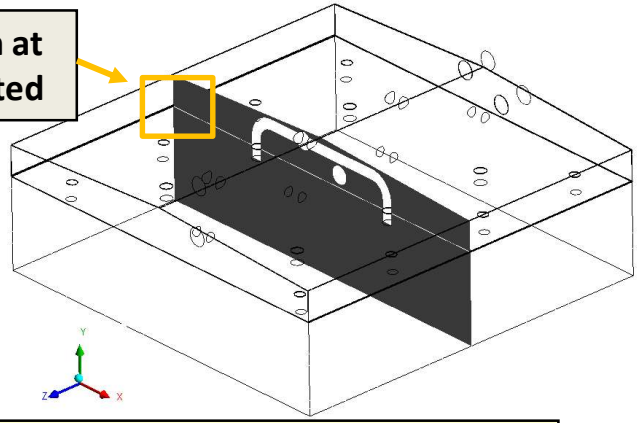
Food Processing Facility Model Results - 2” Insulated



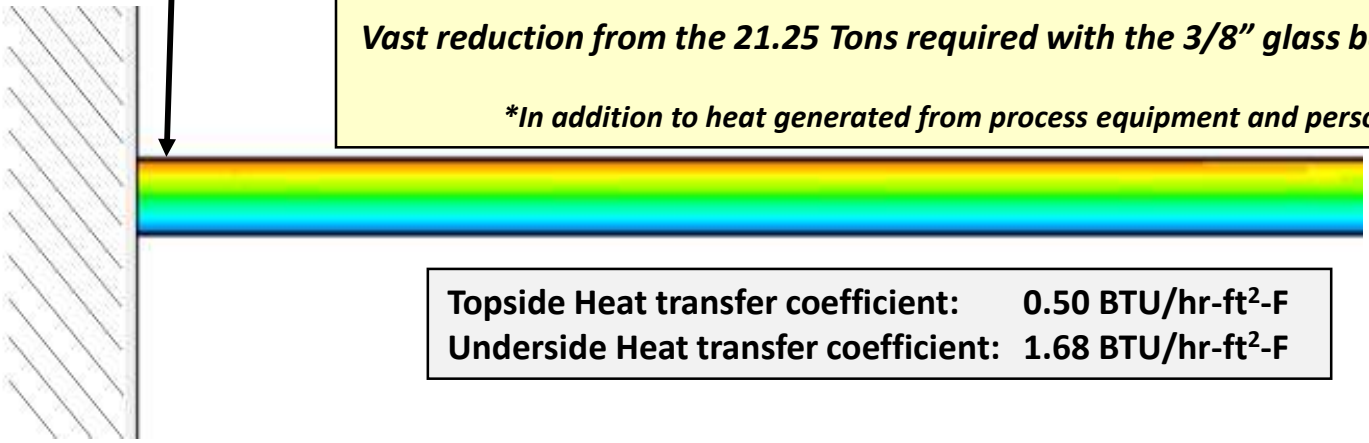
Food Processing Facility Model Results - 2” Insulated



Temperature shown at cross section indicated



Panel Delta T: 67 F



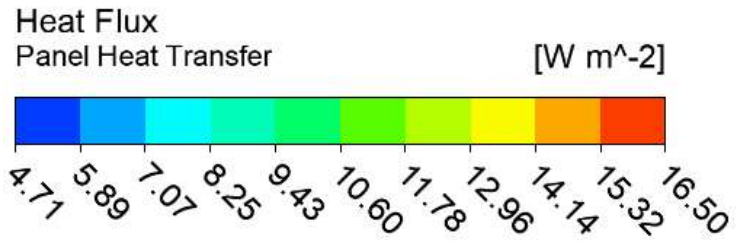
Additional Cooling* needed: ~6.5 Tons (76020 BTU/hr per 10000 ft^2)

Vast reduction from the 21.25 Tons required with the 3/8” glass board panels

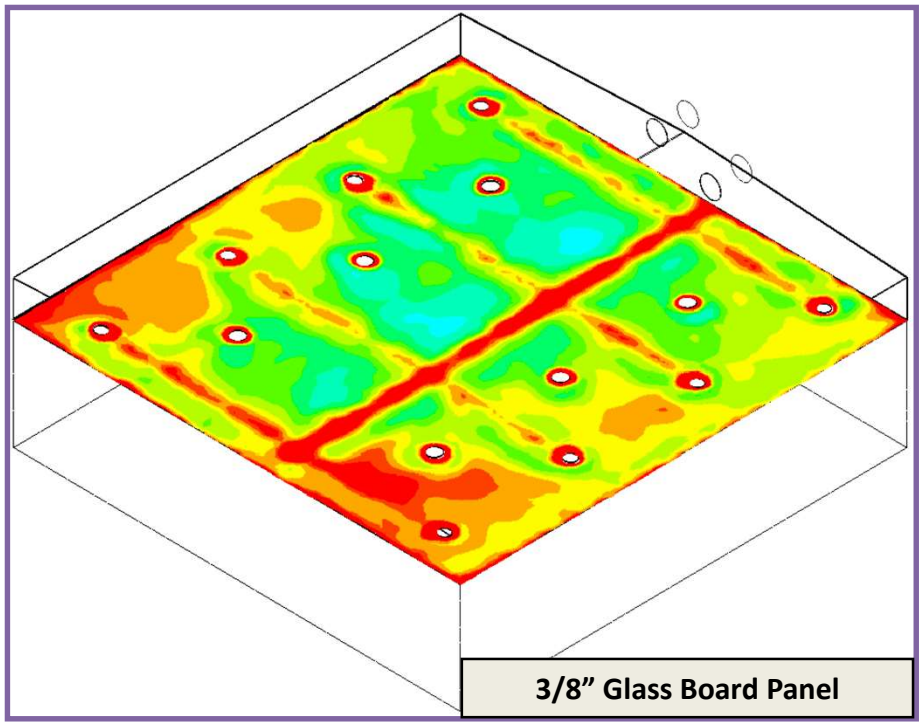
****In addition to heat generated from process equipment and persons***

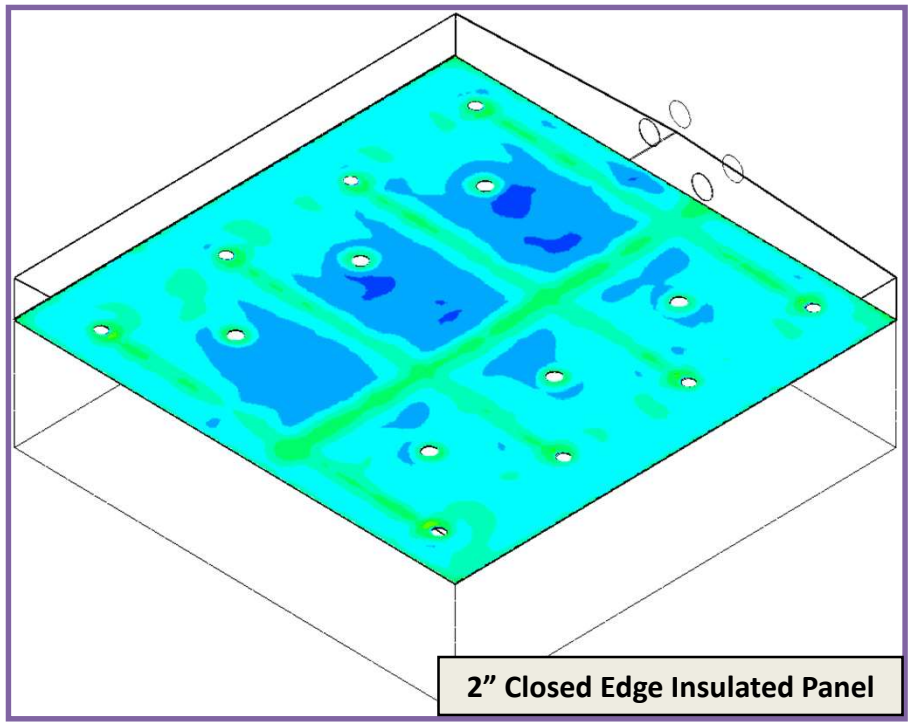
Topside Heat transfer coefficient:	**0.50 BTU/hr-ft^2-F**
Underside Heat transfer coefficient:	**1.68 BTU/hr-ft^2-F**

Food Processing Facility Model - Comparison



The 2” Closed Edge Insulated Panel decreases heat transfer from the interstitial space to the process area by ***70%*** versus the 3/8” Glass Board Panel

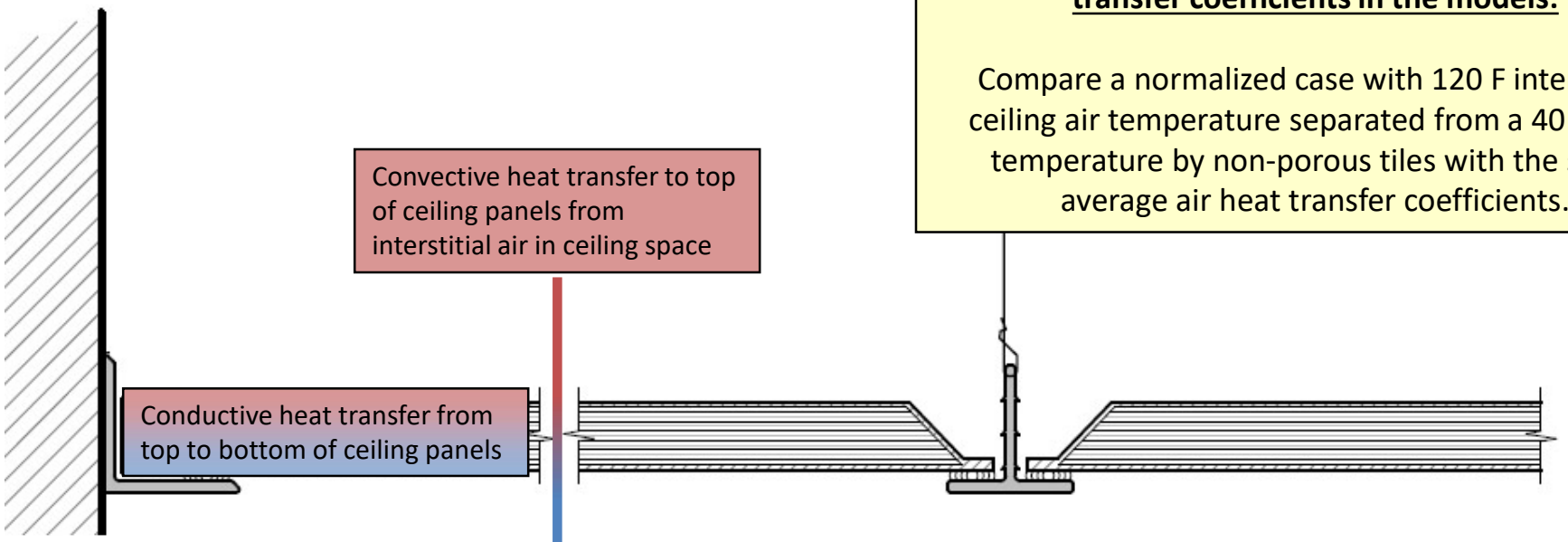




Heat Transfer Pathway

Due to small variations in temperature and heat transfer coefficients in the models:

Compare a normalized case with 120 F interstitial ceiling air temperature separated from a 40 F floor temperature by non-porous tiles with the same average air heat transfer coefficients.



Food Processing Facility Cooling Calculations

$$R_{conduction} = \frac{L}{k} \qquad R_{total} = R_{conv_{ceiling}} + R_{cond_{panels}} + R_{conv_{floor}}$$

$$R_{convection} = \frac{1}{h} \qquad Q_{heat} = \frac{(T_{hot} - T_{cold})\,A}{R_{total}}$$

h	Heat Transfer Coefficient
k	Thermal Conductivity
A	Total Area of Panels
L	Thickness of Panels
T	Temperature
R	Resistance
Q	Heat Transfer

Panel Type	$h_{ceiling}$ (BTU/hr-ft²-F)	h_{floor} (BTU/hr-ft²-F)	K (BTU-in/hr-ft²-F)	L (in)	$R_{conv\_ceiling}$	R_{cond}	R_{conv_floor}	R_{total}
3/8" Glass Board Panel	0.617	1.68	0.698	0.366	1.62	0.524	0.594	**2.739**
2" Closed Edge Insulated Panel	0.617	1.68	0.260	2.171	1.62	8.350	0.594	**10.56**

Panel Type	$T_{ceiling}$ (F)	T_{floor} (F)	A (ft²)	R_{total}	Q (BTU/hr)	AC Sizing
3/8" Glass Board Panel	120	40	10,000	2.739	**292,098**	**+ 24.50 Ton**
2" Closed Edge Insulated Panel	120	40	10,000	10.56	**75,726**	**+ 6.5 Ton**

Heat Transfer for 3/8" Glass Board Panel: **292,098 BTU/hr**
Heat Transfer for 2" Closed Edge Insulated Panel: **75,726 BTU/hr**

Energy Loss Ratio: **3.85**
Will require additional capital investment for a larger AC unit(s)
Additional **18 Tons** of cooling solely due to heat transfer from the interstitial space

Food Processing Facility Air Conditioning Cost

$$EER = \frac{Panel\ Heat\ Transfer\ \left[BTU/_{hr}\right]}{AC\ Input\ Power\ [W]}$$

Panel Type	Average Cost of Electricity in USA (¢/kWh)	Panel Heat Transfer (BTU/hr)	AC Efficiency - EER	AC Power Input (kW)	Additional Cost Per Hour (95 F day) ($)
3/8" Glass Board Panel	14.2	292,098	8.5	34.4	$ 4.88
2" Closed Edge Insulated Panel	14.2	75,726	8.5	8.91	$ 1.27

Panel Type	Summer Cost (95 F day) 5 Months, 12 Hours a Day ($)	Spring/Fall Cost (80 F day) 4 Months, 12 Hours a Day ($)	Winter Cost (65 F day) 3 Months, 12 Hours a Day ($)
3/8" Glass Board Panel	$8,783	$5,110	$2,396
2" Closed Edge Insulated Panel	$2,277	$1,325	$621

Panel Type	Summer Cost (80 F night) 5 Months, 12 Hours a Day ($)	Spring/Fall Cost (65 F night) 4 Months, 12 Hours a Day ($)	Winter Cost (50 F night) 3 Months, 12 Hours a Day ($)	Additional Total Cost Per Year ($)
3/8" Glass Board Panel	$ 6,388	$ 3,194	$ 958	**$ 26,829**
2" Closed Edge Insulated Panel	$ 1,656	$ 828	$ 248	**$ 6,955**
			Savings per year	***$ 19,874***

One year air conditioning cost for 3/8" Glass Board Panel: **$ 26,829**
One year air conditioning cost for 2" Closed Edge Insulated Panel: **$ 6,955**

Savings Per Year for 10,000 ft²: $ 19,874

Food Processing Facility Air Conditioning Cost

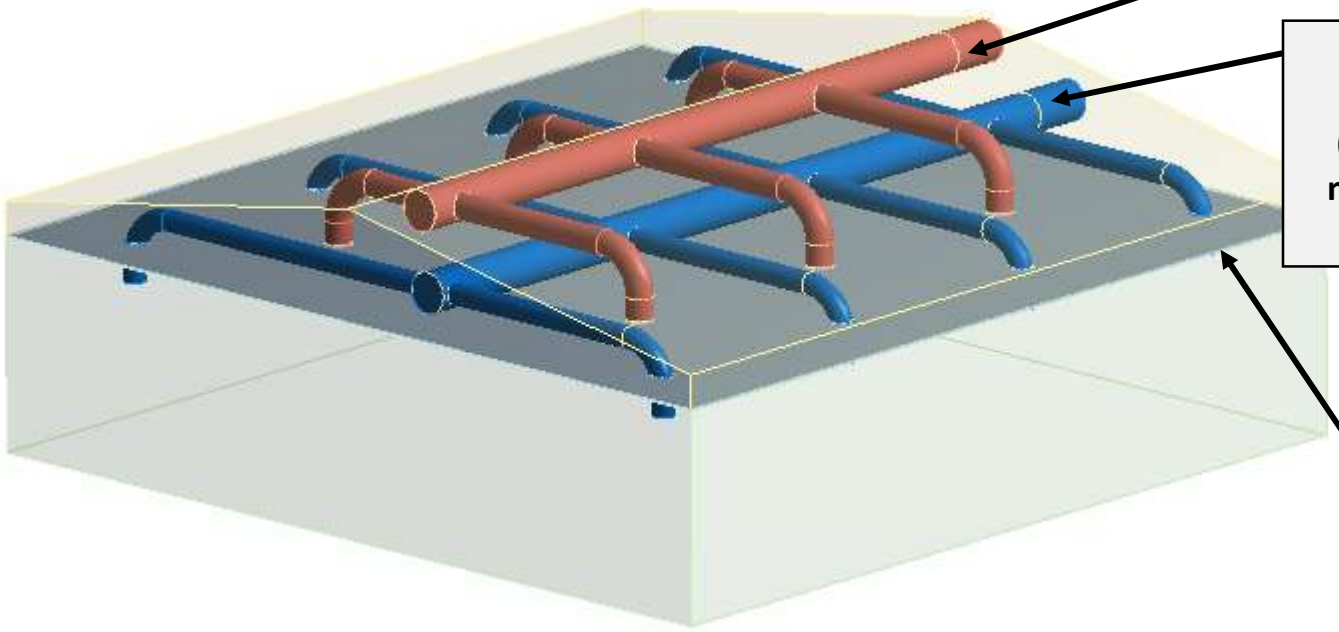
Panel Type	Actual Thickness (in)	R_{cond}	$R_{floor+ceiling}$	Panel Heat Transfer per 10000 ft² (BTU/hr)	AC Sizing*	Additional Cooling* Cost per Year ($)	Savings per year vs. 3/8" Glass board panel ($)
3/8" Glass Board Panel	0.366	0.524	2.214	292,098	+ 24.5 Tons	$ 26,829	
½" Closed Edge Insulated Panel	0.654	2.370	2.214	174,501	+ 14.5 Tons	$ 16,028	$ 10,801
1" Closed Edge Insulated Panel	1.153	4.522	2.214	118,756	+ 10.0 Tons	$ 10,908	$ 15,921
1-½" Closed Edge Insulated Panel	1.678	6.659	2.214	90,155	+ 7.5 Tons	$ 8,281	$ 18,548
2" Closed Edge Insulated Panel	2.171	8.350	2.214	75,726	+ 6.5 Tons	$ 6,955	$ 19,874

* In addition to cooling needed for heat generation from process equipment and persons

Data Center Facility Case Study

10,000 ft^2 Data Center Facility Case Study Model

Dimensions: 100’ x 100’ x 28’
Outside Ambient: 95 F
Solar Load: 1040 W/m^2
Desired Internal Floor Temp: 70 F

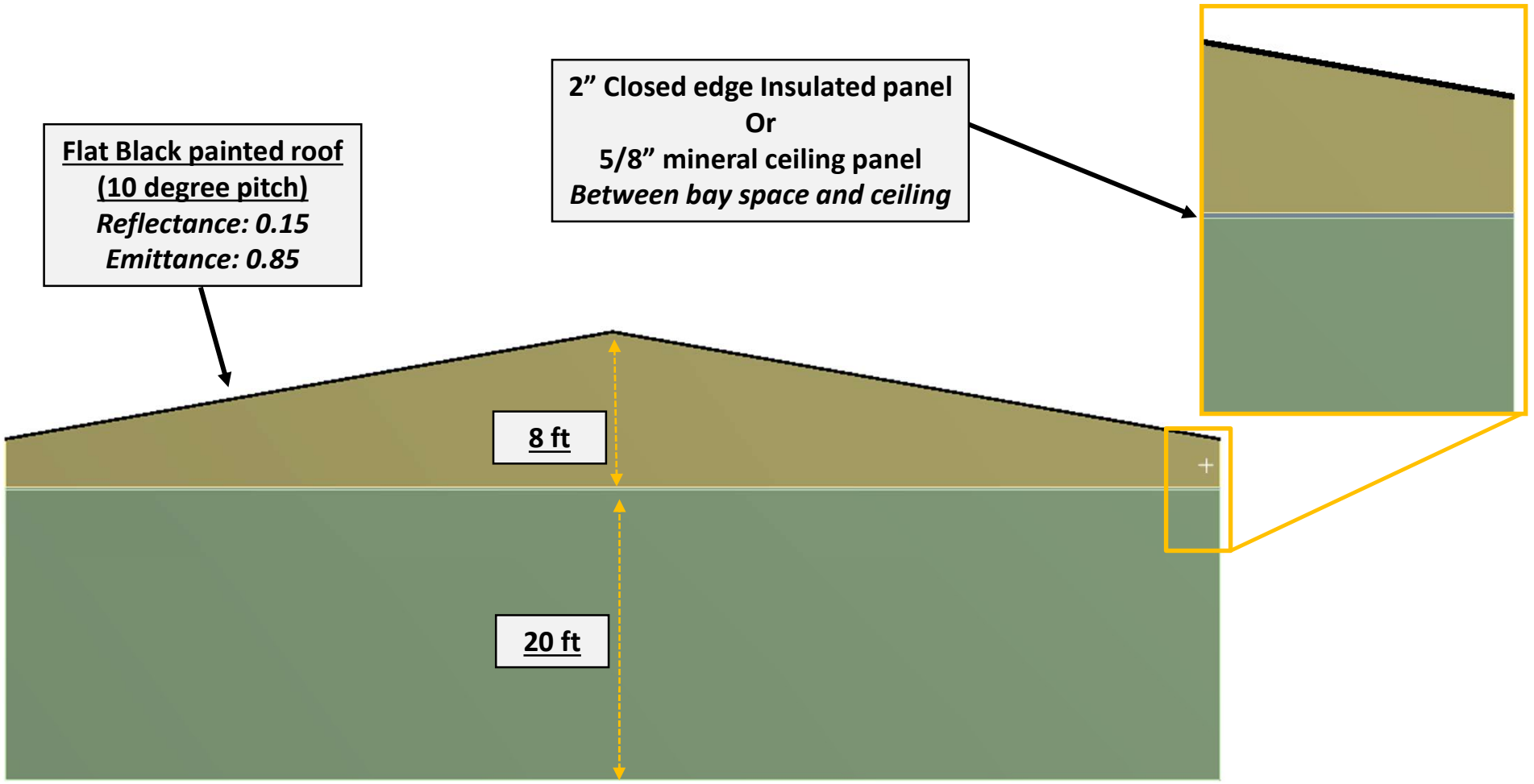


Return Warm Air Return

Conditioned Cool Air Inlet
25 Air exchanges per hour
(In practice this will be much more which exacerbates mass transfer based energy loss)

Ceiling panels
Between bay space and ceiling

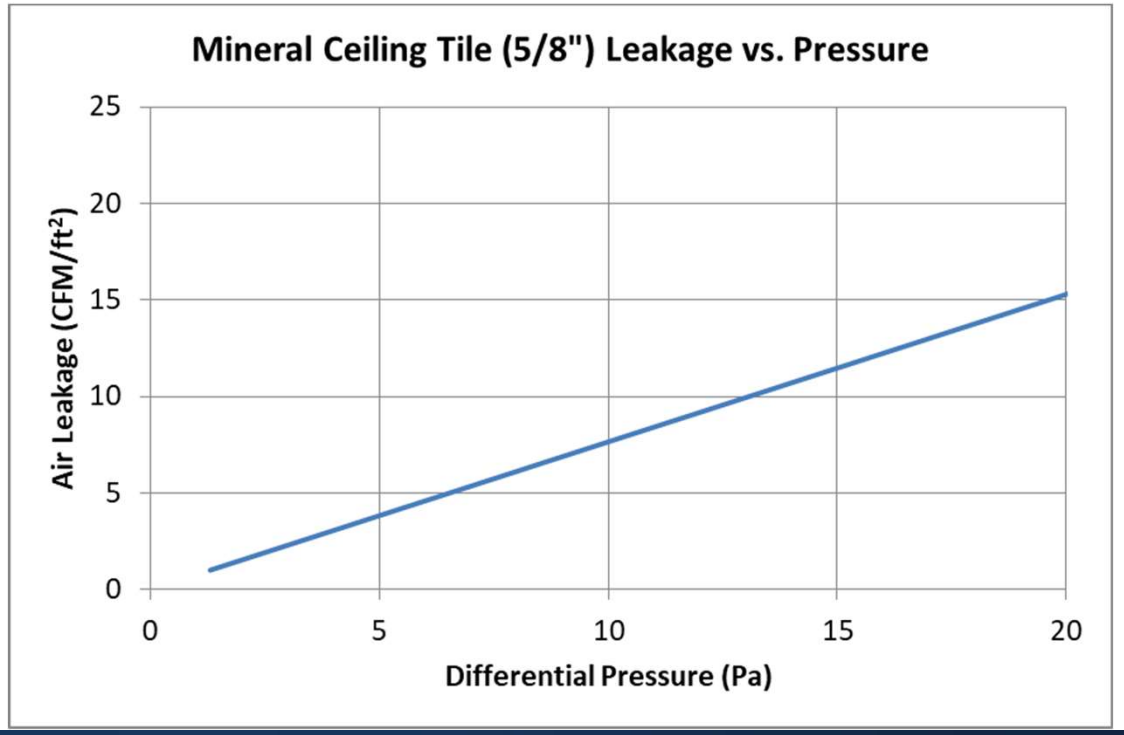
10,000 ft² Data Center Facility Case Study Model



Mineral Ceiling Panels

Equivalent Porosity: 0.8565
Equivalent packed bed bead diam.: 0.0036 inch

Leakage at a building positive pressure of 0.01 inch-H2O: 1.9 CFM/ft²



Ceiling Panel Insulative Properties

Panel	Actual thickness (in)	Thermal Conductivity (W/m-K)	Thermal Conductivity (BTU-in/hr-ft^2-F)	Leakage at 0.01 in-H2O ΔP (CFM/ft^2)
½" Closed Edge Insulation panel, Gel Coat Finish	0.654	0.040	0.276	0.0
1" Closed Edge Insulation panel, Gel Coat Finish	1.153	0.037	0.255	0.0
1-½" Closed Edge Insulation panel, Gel Coat Finish	1.678	0.036	0.252	0.0
2" Closed Edge Insulated panel, Gel Coat Finish	2.171	0.038	0.260	0.0
3/8" glass board panel	0.366	0.101	0.698	0.0
5/8" mineral ceiling panel	0.625	0.055*	0.376*	1.9

***Note: Thermal conductivity assumes no mass transfer effects.**

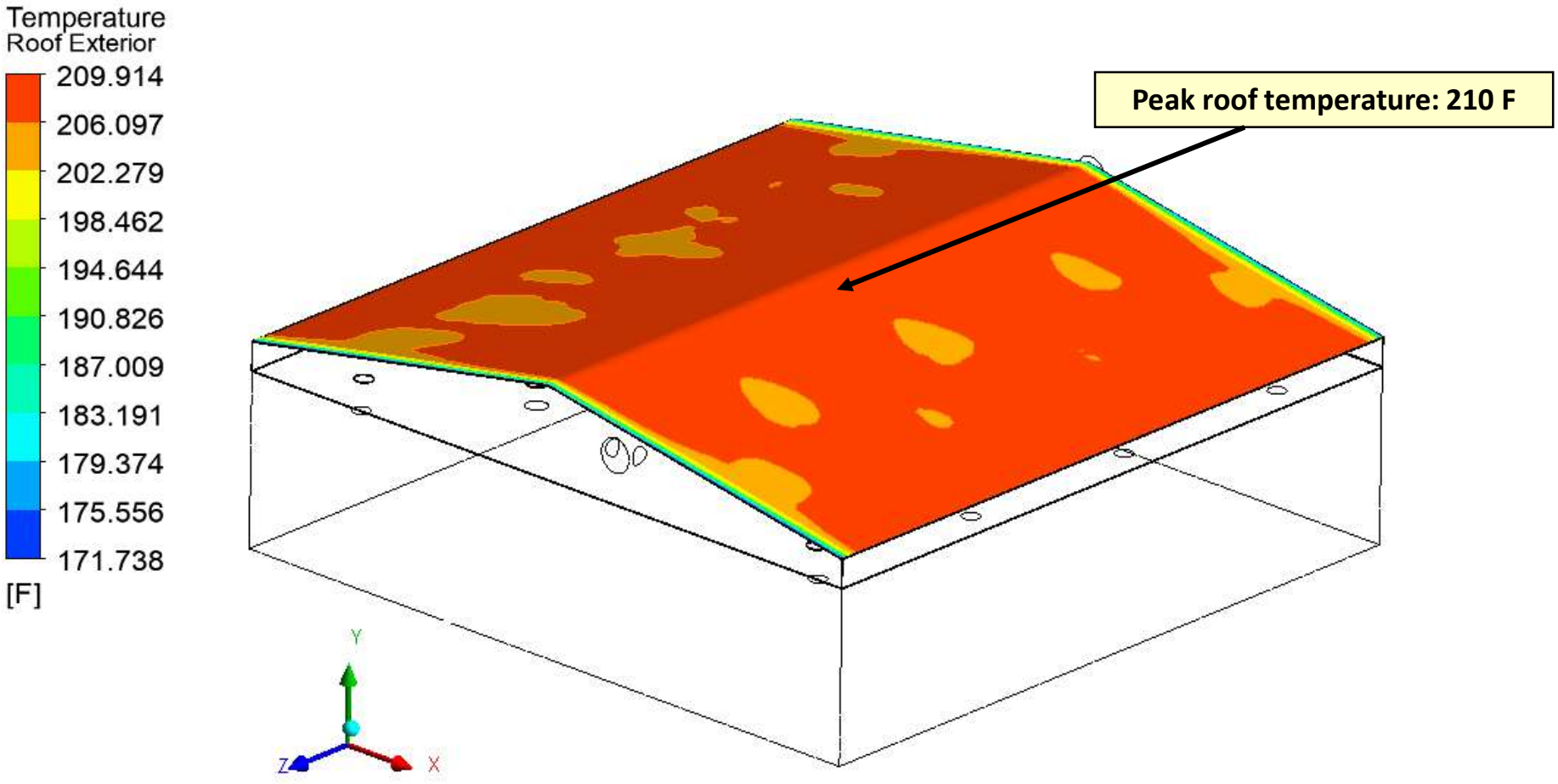
Data Center Facility Case Study

Nominal 2” Closed Edge Insulating Panel, Gel Coat Finish

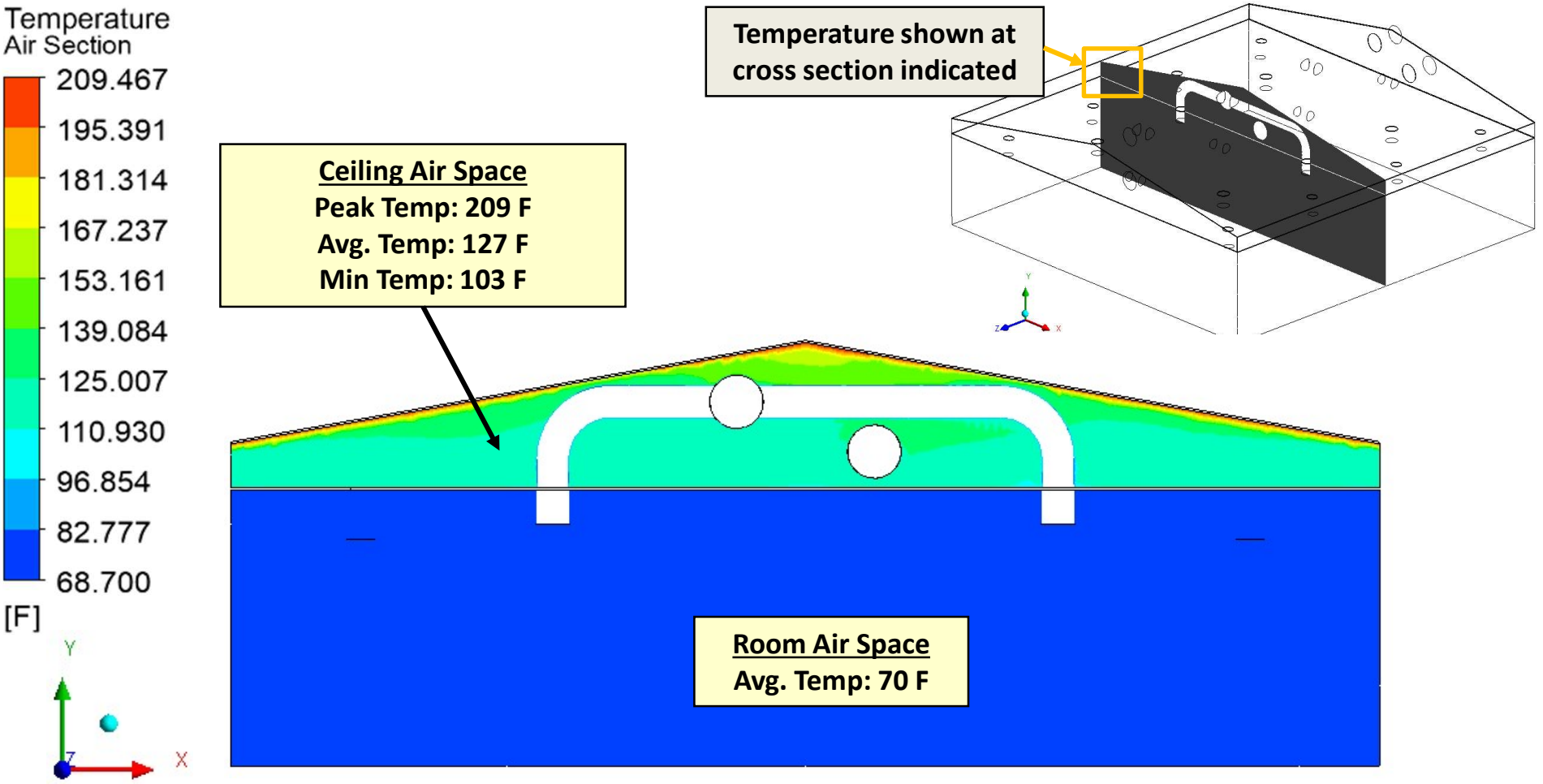
(Actual thickness: 2.171 in)

95 F ambient during the day

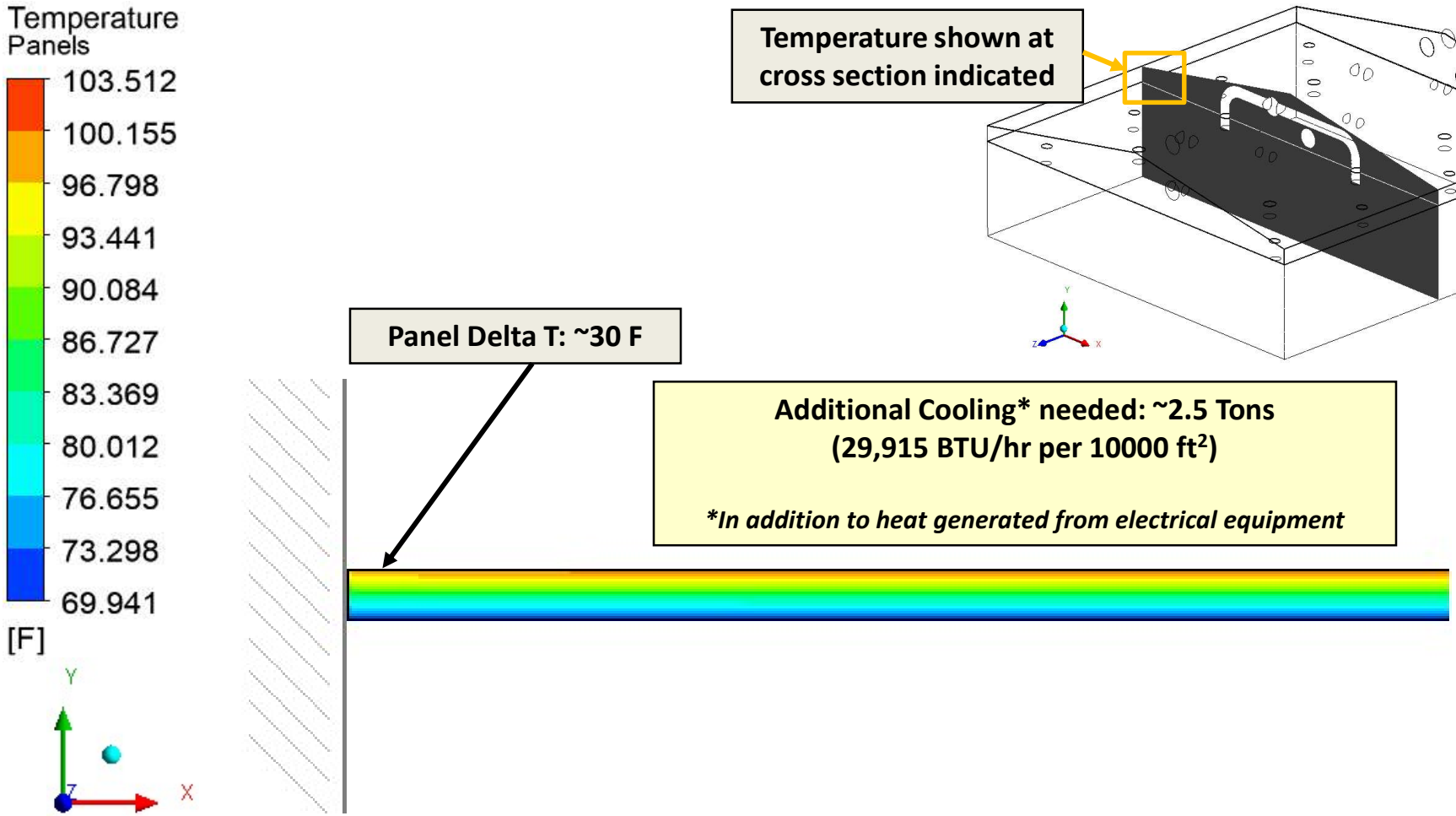
Data Center Facility Model Results – 2” Insulated



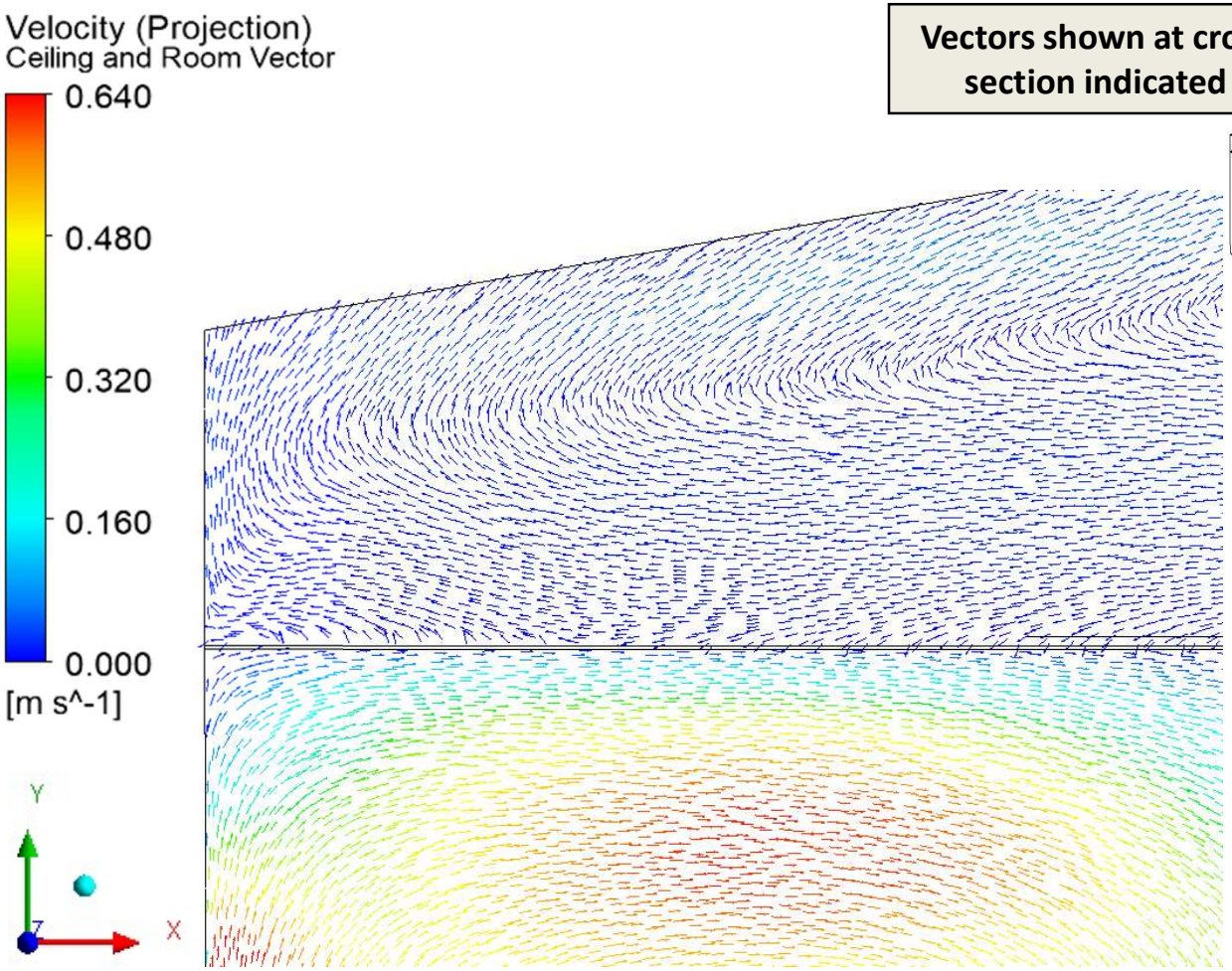
Data Center Facility Model Results – 2” Insulated



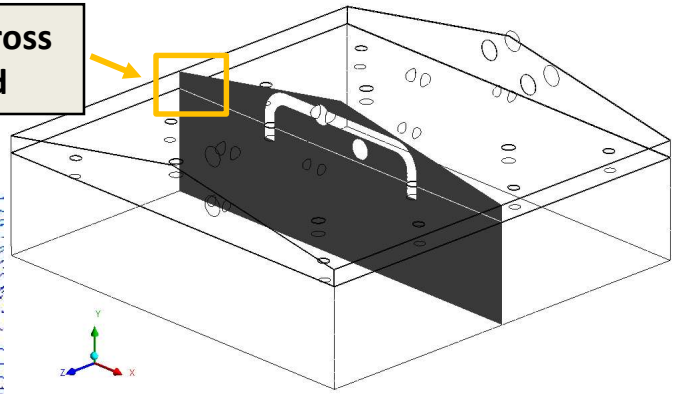
Data Center Facility Model Results – 2” Insulated



Data Center Facility Model Results – 2” Insulated



Vectors shown at cross section indicated



Only method of energy loss is due to convection on either side of ceiling panel and conduction through it.

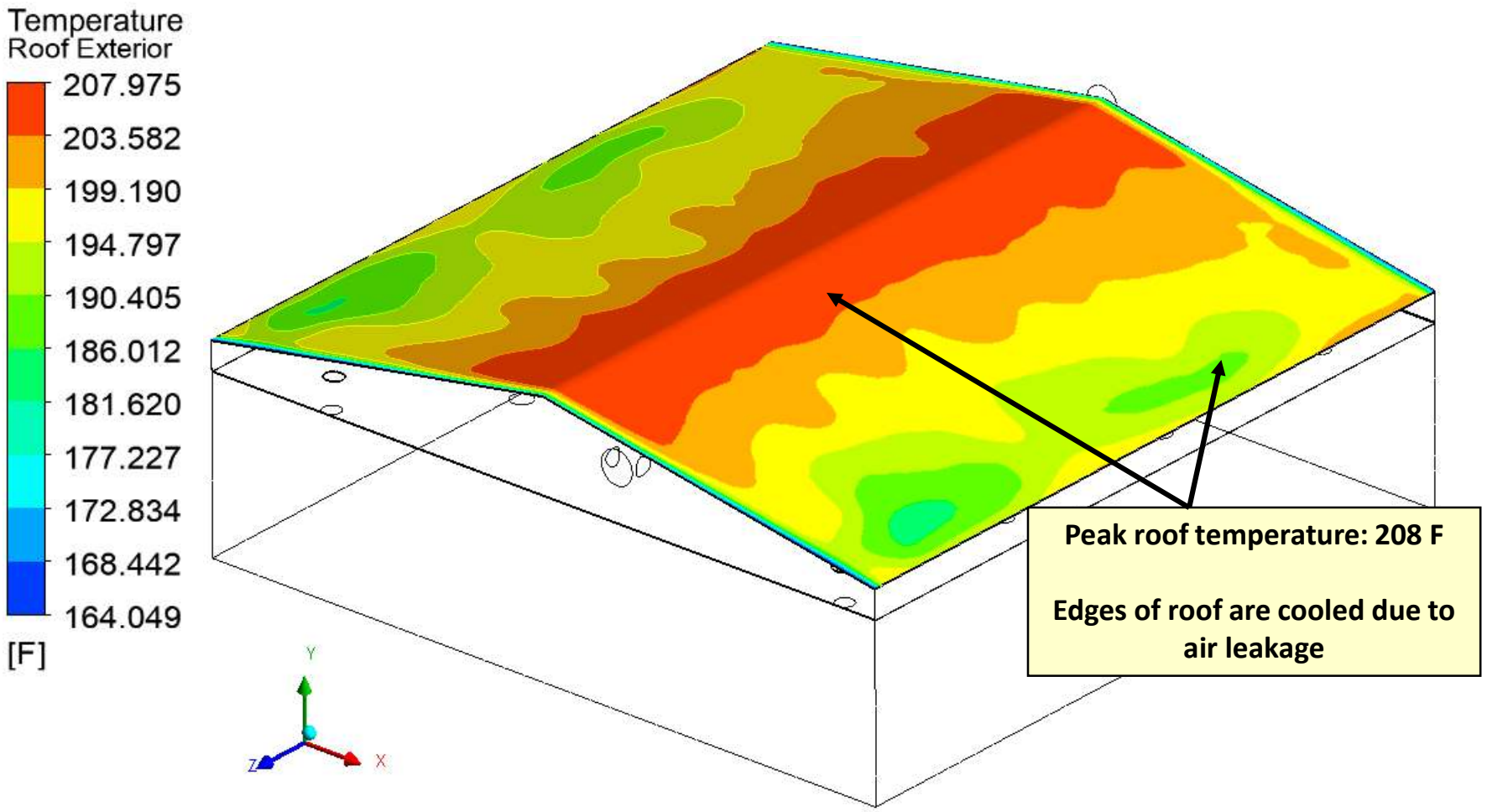
No flow through panels.

Data Center Facility Case Study

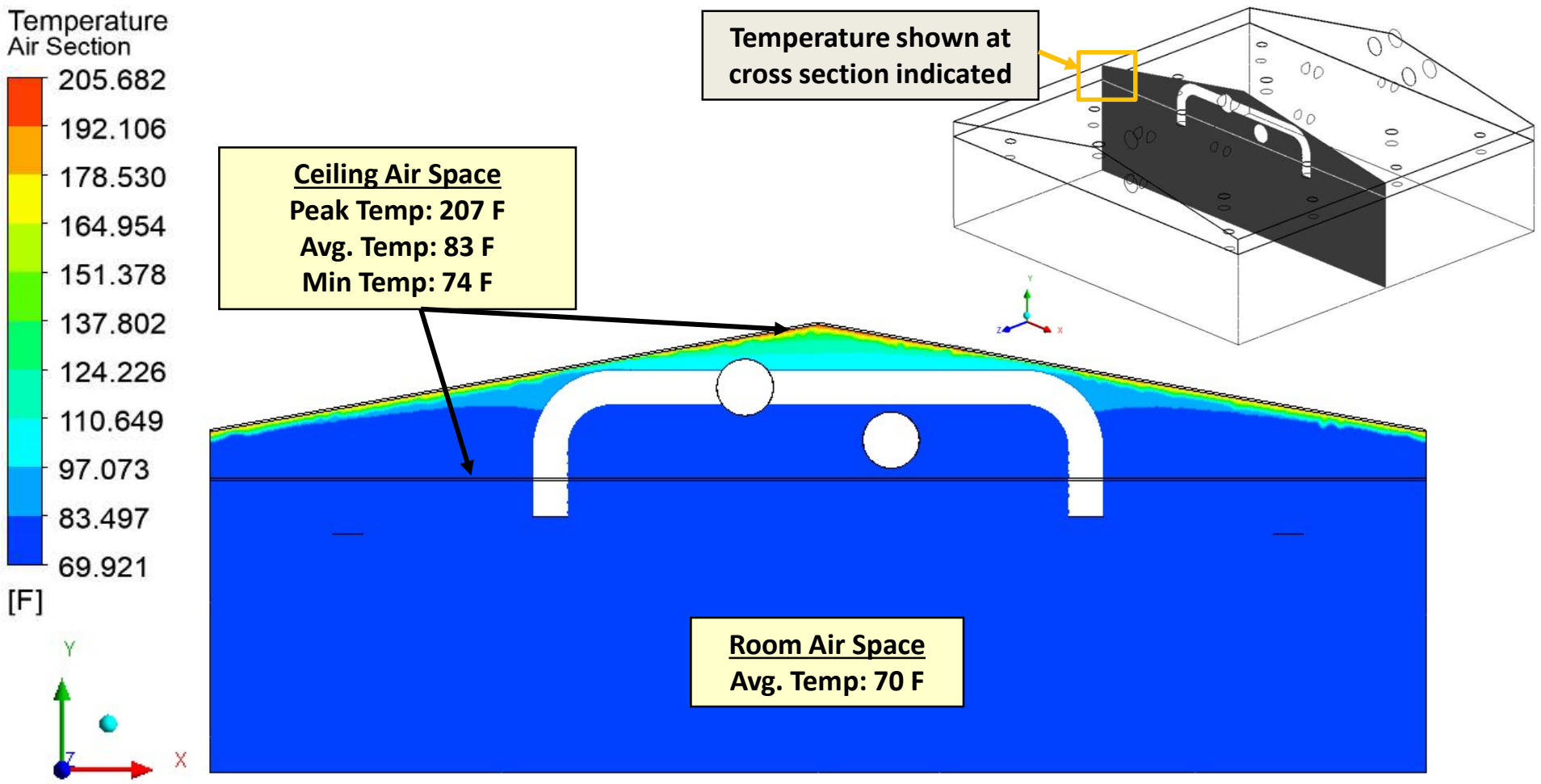
5/8” Mineral Ceiling Tile

95 F ambient during the day

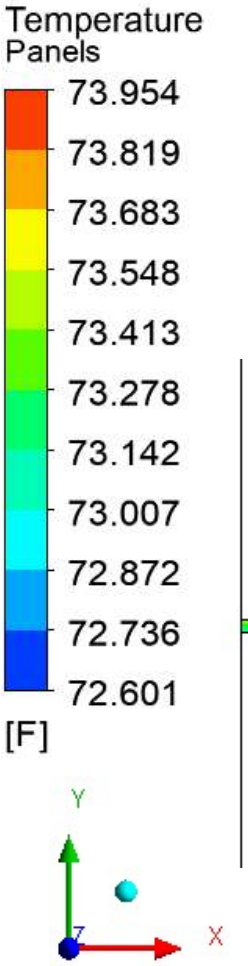
Data Center Facility Model Results – 5/8” Mineral Tile



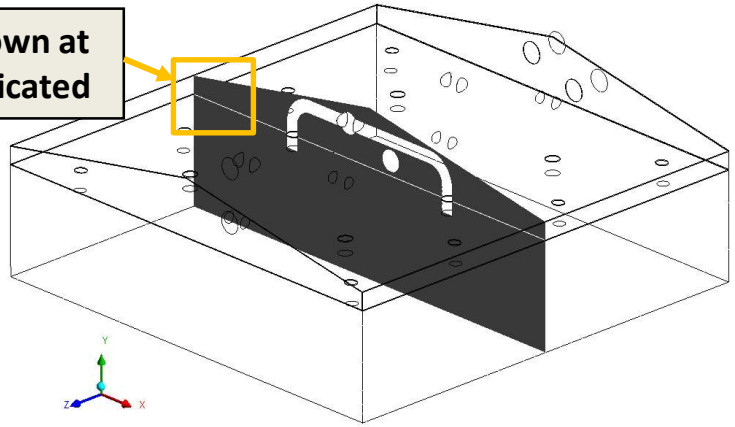
Data Center Facility Model Results – 5/8” Mineral Tile



Data Center Facility Model Results – 5/8” Mineral Tile



Temperature shown at cross section indicated



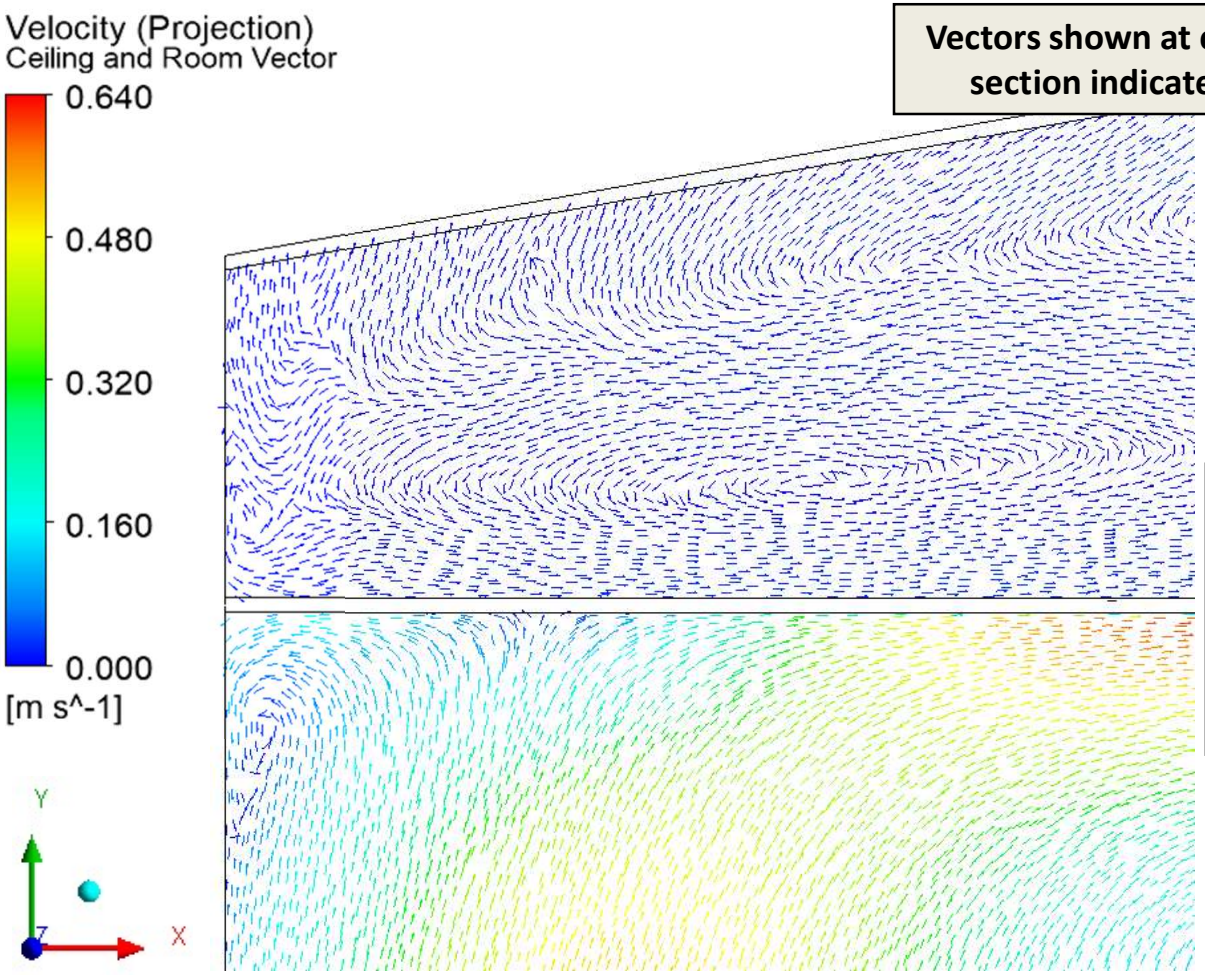
Panel Delta T: < 1 F
Mass transfer effects dominate

Additional Cooling* needed: ~30.0 Tons (359,600 BTU/hr per 10000 ft^2)

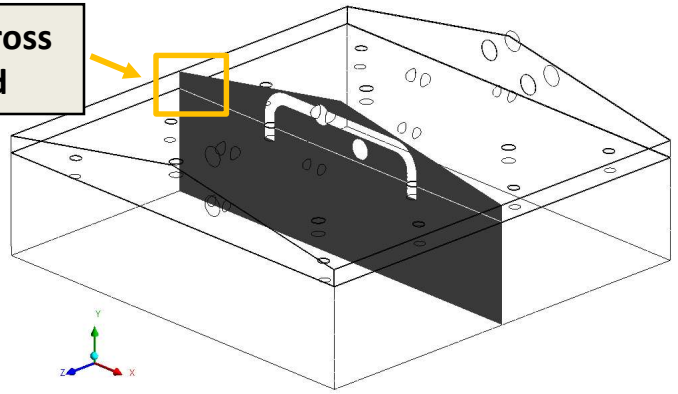
2” Insulated panels only requires an additional 2.5 Tons of cooling

****In addition to heat generated from electrical equipment***

Data Center Facility Model Results – 5/8” Mineral Tile



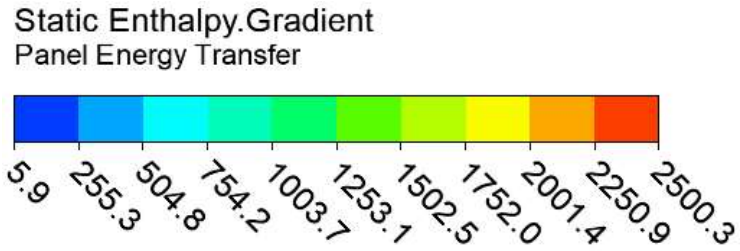
Vectors shown at cross section indicated



Velocities are similar in the room but due to the porosity of the mineral ceiling tiles, air is able to permeate through and reach the hot underside of the roof

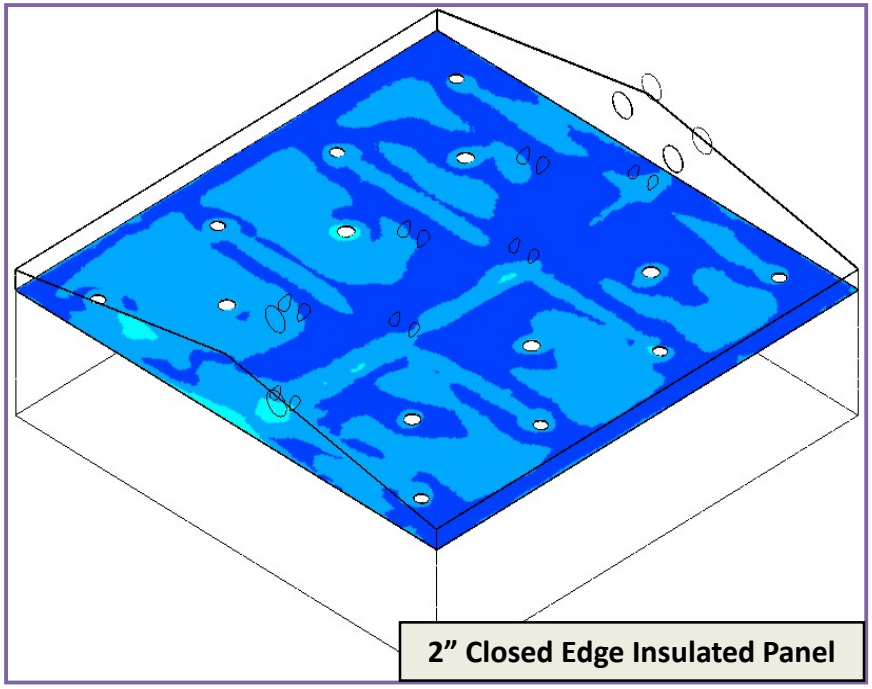
Air permeation rate: 1475 CFM

Data Center Facility Model Comparison

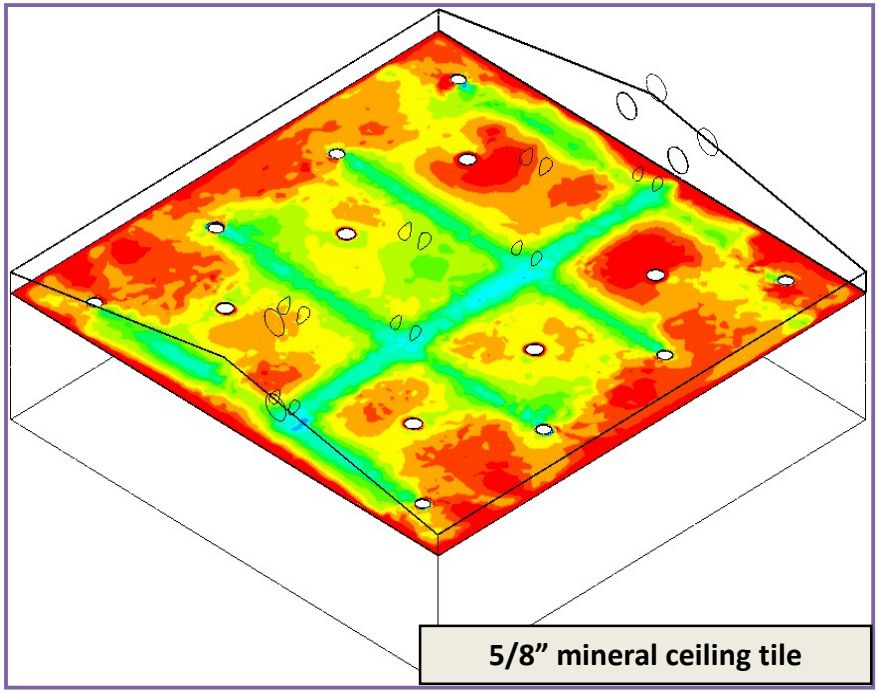


Due to air leakage, heat transfer through the 5/8" mineral ceiling tile is ***12 times*** greater than the 2" Closed Edge insulated panel

Use of mineral ceiling panels would require an additional capital investment of a larger AC unit(s)

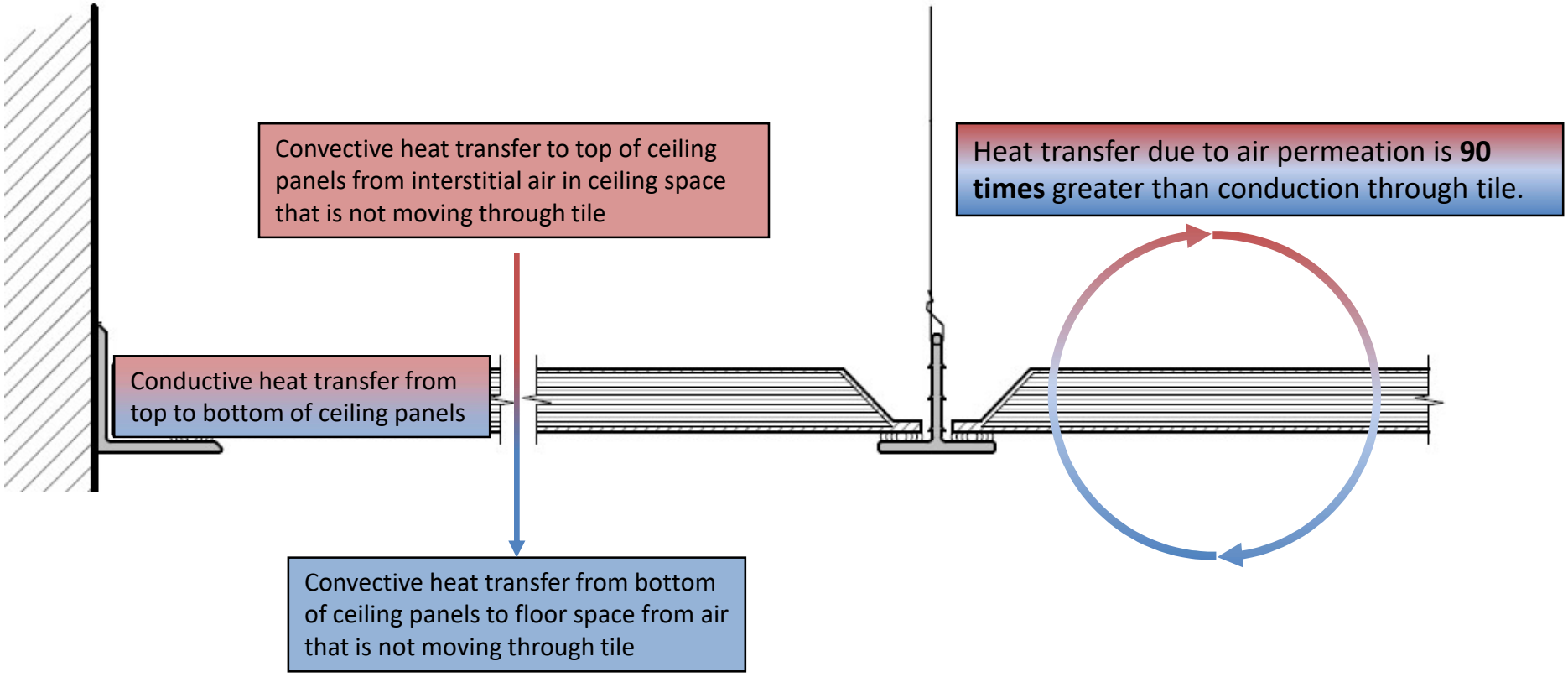


2" Closed Edge Insulated Panel



5/8" mineral ceiling tile

Mineral Ceiling Tile Heat Transfer Pathway



Data Center Facility Air Conditioning Cost

$$EER = \frac{Panel\ Heat\ Transfer\ \left[BTU/_{hr}\right]}{AC\ Input\ Power\ [W]}$$

Panel Type	Average Cost of Electricity in USA (¢/kWh)	Panel Heat Transfer (BTU/hr)	AC Efficiency - EER	AC Power Input (kW)	Additional Cost Per Hour (95 F day) ($)	AC Sizing
5/8" Mineral Ceiling Tile	14.2	359,563	9.5	37.85	$ 5.37	**+ 30.0 Tons**
2" Closed Edge Insulated Panel	14.2	29,915	9.5	3.15	$ 0.45	**+ 2.5 Tons**

Panel Type	Summer Cost (95 F day) 5 Months, 12 Hours a Day ($)	Spring/Fall Cost (80 F day) 4 Months, 12 Hours a Day ($)	Winter Cost (65 F day) 3 Months, 12 Hours a Day ($)
5/8" Mineral Ceiling Tile	$ 9,674	$ 3,096	$ 0
2" Closed Edge Insulated Panel	$ 805	$ 257	$ 0

Panel Type	Summer Cost (80 F night) 5 Months, 12 Hours a Day ($)	Spring/Fall Cost (65 F night) 4 Months, 12 Hours a Day ($)	Winter Cost (50 F night) 3 Months, 12 Hours a Day ($)	Additional Total Cost Per Year ($)
5/8" Mineral Ceiling Tile	$ 3,870	$ 0	$ 0	**$ 16,640**
2" Closed Edge Insulated Panel	$ 321	$ 0	$ 0	**$ 1,384**
			Savings per year	***$ 15,256***

One year air conditioning cost for 5/8" Mineral Ceiling Panel: **$ 16,640**
One year air conditioning cost for 2" Closed Edge Insulated Panel: **$ 1,384**

Savings Per Year for 10,000 ft²: $ 15,256

Data Center Facility Air Conditioning Cost

Panel Type	Actual Thickness (in)	R_{cond}	$R_{floor+ceiling}$	Panel Heat Transfer per 10000 ft² (BTU/hr)	AC Sizing*	Additional Cooling* Cost per Year ($)	Savings per year vs. 5/8" Mineral ceiling tile ($)
5/8" Mineral Ceiling Tile	0.625			359,563	+ 30.0 Tons	$ 16,640	
3/8" Glass Board	0.366	0.524	1.678	136,189	+ 11.5 Tons	$ 6,302	$ 10,338
½" Closed Edge Insulated Panel	0.654	2.370	1.678	74,110	+ 6.25 Tons	$ 3,430	$ 13,210
1" Closed Edge Insulated Panel	1.153	4.522	1.678	48,387	+ 4.0 Tons	$ 2,239	$ 14,401
1- ½" Closed Edge Insulated Panel	1.678	6.659	1.678	35,983	+ 3.0 Tons	$ 1,665	$ 14,975
2" Closed Edge Insulated Panel	2.171	8.350	1.678	29,915	+ 2.5 Tons	$ 1,384	$ 15,256

The majority of the cost savings is due from preventing the air from permeating the interstitial space

* In addition to cooling needed for heat generation from electrical equipment